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TRANSPORTING

BALES OF COTTON

WITH LARGE CLAMP TRUCKS

U.S. DEPARTMENT OF AGRICULTURE/AGRICULTURAL RESEARCH SERVICE

CONTENTS

SUMMARY

Cotton warehousemen using separated storage compartments and open storage yards might well consider the new large clamp trucks for transport distances of 1,000 feet and over. These trucks, capable of carrying unit loads of 12, 16, 20, and even more bales, can replace, or supplement, tractor-trailer trains that have been commonly used for transporting bales under these conditions.

Two 3-bale clamp trucks are used to assemble and disassemble the bales transported by one large clamp truck. The three men operating the equipment can work almost independently of each other so there is little wait time for any of the operators. In contrast, three workers and their equipment are tied up for the entire time it takes to load and unload bales and transport them with a tractor-trailer train. Two 3-bale clamp trucks are used to load and unload tractor-trailer trains.

TRANSPORTING BALES OF COTTON WITH LARGE CLAMP TRUCKS

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BACKGROUND

In large warehouses transport distances of 1,000 feet and over are often involved in moving cotton bales from receiving to storage areas and from storage areas to compress compartments or shipping areas. This is particularly true in the West and Southwest where separated compartments and open storage yards are commonly used. Such warehouses need carriers that can transport large unit loads of bales rapidly enough to keep up with storage, compressing, and shipping operations.

Tractor-trailer trains (a tractor pulling at least four trailers, each capable of holding four flat or compressed bales) are commonly used for transporting bales long distances on warehouse sites. Large clamp trucks, capable of carrying unit loads of 12, 16, or 20 bales, are relatively new.

A study was made to compare labor and equipment requirements and costs of transporting on the warehouse site by large clamp trucks and by tractor-trailer trains.

LARGE CLAMP TRUCKS

Two sizes of large clamp trucks were studied; they are identified in this report as Truck No. 1 (the larger of the two) and Truck No. 2.

Truck No. 1 weighs about 23,000 pounds and is capable of carrying unit loads of 16 flat bales (weighing about 8,000 pounds) or 20 compressed bales (weighing about 10,000 pounds). This machine is about 95 inches wide and 170 inches long (fig. 1). The width provides a stable base for loads extending 30 inches beyond the width of the machine. Turning radius for a machine of this size is about 160 inches. These machines are commonly equipped with power steering, power brakes, and 4- or 5-speed transmissions. They can travel at speeds up to 30 miles per hour. Either gasoline or LPG is used to power the 126- to 130-horsepower engines. Average fuel consumption is 2 to 3 gallons of gasoline or 3 to 4 gallons of LPG per hour.[1/]

1/ Data were obtained on gas consumption over distances of 500 to 2,500 feet. Included were starts, stops, turns in uncongested areas, movement over straight runs of transporting, and the pickup and setdown of unit loads.

Figure 1.--Truck No. 1 picking up a load of 16 flat bales.

Clamps on this truck are hydraulic and are made of 4-by-15-inch U-beams that weigh about 6,500 pounds. Clamp arms are 74 to 76 inches long; they can be opened to a width of 11 feet and closed to a width of 2½ feet. A superstructure of 2-inch diameter pipe is attached to the clamp faceplate and arms to keep the upper tier of bales carried in two tiers from falling.

Truck No. 2 weighs about 15,000 pounds and can carry unit loads of 12 flat bales (weighing about 6,000 pounds) or 16 compressed bales (weighing about 8,000 pounds).2/ This machine is 77 inches wide and 115 inches long. Loads can extend 20 inches beyond the machine width. The turning radius of this truck is 135 inches. Power steering and brakes are standard equipment, as well as a power shift, 4-speed transmission. Fuel consumption varies, but the average is 1 to 2 gallons of gasoline or 2 to 3 gallons of LPG per hour. This machine has a 70- to 80-horsepower engine and travels at 15 to 20 miles per hour.

Clamps on this machine are similar in design to those on Truck No. 1, but are made of 4-by-12-inch U-beams and weigh about 5,500 pounds.

Both sizes of large clamp trucks are usually equipped with dual pneumatic tires and can move in lightly compacted and sandy soil, although they operate better on asphalt or concrete floors and yards.

Large clamp trucks cannot be used inside compartments having 10-by-10-foot door openings, wooden or elevated floors, narrow receiving and shipping platforms, or platforms with roofs less than 12 feet high. If the trucks are to move into a compartment, doorways should be 14 feet wide and 16 feet high and at ground level.

2/ No studies were made of a 10,000-pound clamp truck carrying compressed bales but, based on tests with larger machines, 16 compressed bales could be carried.

Loads of bales for the large clamp trucks are assembled and disassembled by 3-bale clamp trucks carrying 2, 3, or 4 bales per trip. To assemble unit loads of 12 flat bales, the operator of the 3-bale clamp truck sets down 3 bales on head to form the first tier, and then places 3 bales on head on top of these to form a second tier. The remaining 6 bales are assembled in the same way to complete the 12-bale load as shown in figure 2.

Figure 2.--Truck No. 2 with a load of 12 flat bales.

To build a unit load of 16 flat bales, the operator assembles the first 12 bales as just described. He then sets down two bales at the end of each row, picks up the outer two bales and places them on top of the other two.

Unit loads of 20 compressed bales (standard density) are assembled in much the same manner as unit loads of 16 flat bales, except that the 3-bale clamp truck carries 4 bales at a time to assemble the first 16 bales. The last four bales are added two bales at a time to complete the 20-bale load (fig. 3).

The unit loads are disassembled in much the same manner as they are assembled.

The labor requirements and elapsed time for transporting bales by large clamp trucks were computed for distances ranging from 500 to 2,500 feet. Three men are required: One operator assembles unit loads with a 3-bale clamp truck, the second transports the loads with the large clamp truck, and the third disassembles loads with a 3-bale clamp truck. The bales are assembled

and disassembled outside of compartments; operators of the 3-bale clamp trucks move the bales a distance of 50 feet to or from a temporary block while assembling and disassembling unit loads. Once sufficient unit loads have been assembled for the large clamp truck to start transporting, the three men can work almost independently of each other, so there is little if any wait time for any of the operators.

Figure 3.--Truck No. 1 with a load of 20 compressed bales.

Table 1 shows the elapsed time and labor required for three men to transport 100 flat or compressed bales by Truck No. 1 for distances of 500, 1,000, 1,500, 2,000, and 2,500 feet. Table 2 gives the same information for Truck No. 2.

The man-hours required for each part of the operation are the same as the elapsed time, and the total man-hours for assembling, transporting, and disassembling are the total of the three elapsed times. The elapsed time required for the entire operation may be considered to be the transport time of the large clamp trucks, since the three parts of the operation can be performed independently of each other. The transport time may be longer or shorter than assembly or disassembly time depending on the distance bales are transported. This must be taken into consideration when estimating the cost of operating the two 3-bale clamp trucks used in the transport operation (see table 4).

Table 1.--Truck No. 1: Elapsed time and man-hours required for three men to transport 100 flat or compressed bales of cotton for distances of 500 to 2,500 feet

/Includes assembling and disassembling of unit loads by 3-bale clamp trucks/

Unit loads and work performed	Elapsed time1/when transporting distance is--				
	500 ft.	1,000 ft.	1,500 ft.	2,000 ft.	2,500 ft.
	Hours	Hours	Hours	Hours	Hours
Flat bales (16-bale unit loads):					
1 operator with 3-bale clamp truck moves bales 50 feet from block and assembles them into unit loads	0.38	0.38	0.38	0.38	0.38
1 operator with large clamp truck picks up, transports, and sets down 16-bale loads, and returns empty	3/ .30	3/ .34	3/ .39	3/ .44	3/ .49
1 operator with 3-bale clamp truck disassembles unit loads and moves bales 50 feet to block	.35	.35	.35	.35	.35
Total man-hours2/.....	1.03	1.07	1.12	1.17	1.22
Compressed bales (20-bale unit loads):					
1 operator with 3-bale clamp truck moves bales 50 feet from block and assembles them into unit loads	.39	.39	.39	.39	.39
1 operator with large clamp truck picks up, transports, and sets down 20-bale loads, and returns empty	3/ .27	3/ .30	3/ .34	3/ .37	3/ .40
1 operator with 3-bale clamp truck disassembles unit loads and moves bales 50 feet to block	.36	.36	.36	.36	.36
Total man-hours2/.....	1.02	1.05	1.09	1.12	1.15

1/ Elapsed time for the large clamp truck includes 0.22 hour in each case to pick up and set down unit loads.

2/ Total man-hours required for the three parts of the operation.

3/ Considered elapsed time for the entire operation.

Table 2.--Truck No. 2: Elapsed time and man-hours required to transport 100 flat bales of cotton in 12-bale unit loads for distances of 500 to 2,500 feet

/Includes assembling and disassembling of unit loads by 3-bale clamp trucks/

Work performed	Elapsed time[1] when transporting distance is--				
	500 ft.	1,000 ft.	1,500 ft.	2,000 ft.	2,500 ft.
	Hours	Hours	Hours	Hours	Hours
1 operator with a 3-bale clamp truck moves bales 50 feet from block and assembles them into unit loads	0.36	0.36	0.36	0.36	0.36
1 operator with a large clamp truck picks up, transports, and sets down 12-bale loads, and returns empty	3/ .35	3/ .45	3/ .55	3/ .66	3/ .78
1 operator with a 3-bale clamp truck disassembles unit loads and moves bales 50 feet to block	.34	.34	.34	.34	.34
Total man-hours[2]	1.05	1.15	1.25	1.36	1.48

1/ Elapsed time for the large clamp truck includes 0.19 hour in each case to pick up and set down unit loads.

2/ Total man-hours required for the three parts of the operation.

3/ Considered elapsed time for the entire operation.

TRACTOR-TRAILER TRAINS

A tractor-trailer train as used in this report consists of four industrial trailers pulled one behind the other by a tractor. Each trailer can carry four flat bales on head or four compressed bales in a horizontal position. Tractors are usually of the type used on farms, converted to inplant use by the warehouseman. Most tractors weighing from 1,500 to 2,500 pounds have a draw-bar pull of 6,000 to 8,500 pounds. Trailers are usually 2 feet wide and 10 to 12 feet long. The trailer bed is made of metal bar framing. Each trailer has a 4- to 5-foot hitch bar for coupling onto the trailer ahead.

Tractor-trailer trains usually have a traveling speed of 5 to 7 miles per hour; gas consumption averages 1 gallon per hour.

This equipment can enter warehouse compartments where floors or other structural members would not permit the use of the heavier clamp trucks. The trailers are usually loaded and unloaded by 3-bale clamp trucks. Loading and unloading must take place in an area where the trains can move straight ahead and do not have to back up. There must also be sufficient space for the

trains to turn around. Posts in the compartment often make it difficult for clamp trucks to approach the trailers at the correct angle to pick up a full load of bales. When the trains must move around posts, bales are often knocked off or the posts are damaged.

Loading and unloading a trailer with compressed bales requires more time than flat bales. Both types of bales are handled two at a time. Compressed bales are picked up by clamp trucks from an on-head position. Then the clamps are loosened slightly and the bales lowered to a horizontal position. Bales are again picked up, moved to the trailer and set down on the trailer bed in a horizontal position. When unloading the trailers, two bales are picked up in a horizontal position, moved clear of the trailer, and set down. Then the truck moves the bales to an on-head position, picks them up again, moves them to a temporary block, and sets them down.

A major difference between use of tractor-trailer trains and large clamp trucks is that with the trains, three workers and their equipment are tied up for the total time it takes to load and unload bales and transport them. Two operators and two 3-bale clamp trucks must wait while the train is transporting bales, and the tractor operator must wait while trailers are loaded and unloaded. Many warehousemen add tractor-trailer trains to the transporting operation until the loaders and unloaders have as little wait time as possible. This reduces the total time for the operation and generally also reduces labor and equipment costs.

Labor and equipment requirements in this report were computed on the basis of using one tractor-trailer train and two 3-bale clamp trucks for each transport distance studied. The trailers are loaded and unloaded in the main aisle of the warehouse compartment. Operators of 3-bale clamp trucks pick up two bales at a time while loading or unloading and transport them 20 feet to or from a temporary block.

Table 3 shows the elapsed time and labor requirements for three men to transport 100 flat or compressed bales, in 16-bale unit loads, by tractor-trailer trains. Since two workers are always waiting while the third one is performing his part of the operation, the elapsed time for the operation is the total of the times for each part, and the man-hours required are three times the total elapsed time. The table illustrates the desirability of using more than one train when the transport time is considerably greater than either the loading or the unloading time. For example, when one train transports 100 bales 1,500 feet, the total elapsed time is 1.17 hours and 3.51 man-hours are required. When two trains are used, the transport time is reduced by one-half with the total elapsed time being reduced to 0.83 hour (0.25 + 0.33 + 0.25), a reduction of 0.33 hour per 100 bales. The addition of the second train will increase the cost per hour for the trains but this cost will be offset by the saving in equipment time charged to the two 3-bale clamp trucks. Although one extra tractor operator is added, the total man-hours are reduced from 3.51 to 3.32 (4 x 0.83), a reduction of 0.19 man-hour per 100 bales. As the transport distance increases, the possibility of savings in time and labor also increases. However, careful consideration must be given to the number of tractor-trailer trains that can be used effectively to prevent purchasing too many.

Table 3.--Tractor-trailer train: Elapsed time and man-hours required for three men to transport 100 flat or compressed bales of cotton in 16-bale unit loads for transport distances of 500 to 2,500 feet[1/]

/Includes loading and unloading trailers by 3-bale clamp trucks/

Unit loads and work performed	Elapsed time when transporting distance is--				
	500 ft.	1,000 ft.	1,500 ft.	2,000 ft.	2,500 ft.
	Hours	Hours	Hours	Hours	Hours
Flat bales:					
1 operator with 3-bale clamp truck moves bales 20 feet from block and loads them on head on trailers	0.25	0.25	0.25	0.25	0.25
1 operator with tractor-trailer train transports 16-bale loads, and returns empty	.26	.47	.67	.88	1.09
1 operator with 3-bale clamp truck unloads trailers and moves bales 20 feet to temporary block	.25	.25	.25	.25	.25
Total elapsed time	.76	.97	1.17	1.38	1.59
Total man-hours	2.28	2.91	3.51	4.14	4.77
Compressed bales:					
1 operator with 3-bale clamp truck moves bales 20 feet from block and loads them in a horizontal position on trailers	.33	.33	.33	.33	.33
1 operator with tractor-trailer train transports 16-bale loads, and returns empty	.26	.47	.67	.88	1.09
1 clamp truck unloads trailers and moves bales 20 feet to temporary block	.41	.41	.41	.41	.41
Total elapsed time	1.00	1.21	1.41	1.62	1.83
Total man-hours	3.00	3.63	4.23	4.86	5.49

1/ Labor requirement data are from supplement to Marketing Research Report No. 250, "Statistical Supplement to Handling Bales of Cotton in Public Warehouses."

COMPARISON OF LABOR AND EQUIPMENT COSTS

Table 4 compares some estimated labor and equipment costs for transporting different quantities of bales for different distances using the two large clamp trucks and a tractor-trailer train. The elapsed times and man-hours used in table 4 are from tables 1, 2, and 3; the equipment costs from table 5.

The number of bales transported in table 4 is twice the number of bales actually received. For example, assume that 50,000 flat bales received at a warehouse are transported an average distance of 1,000 feet to storage. Later they are moved 1,000 feet to the compress. This is equivalent to transporting 100,000 bales 1,000 feet. In this case the estimated cost for transporting is about 3 cents per bale less with Truck No. 2 than with a tractor-trailer train.

Note in table 4 that the estimated cost of transporting 150,000 bales 1,500 feet is less for Truck No. 2 with a unit load of 12 bales than for Truck No. 1 carrying 16-bale unit loads. This is due to the higher equipment cost for 585 hours of use for the larger truck than for 825 hours for the smaller truck (see table 5). Warehousemen can use the costs given in tables 4 and 5 for estimating the size and type of transporting equipment that will be the most practical and economical for their use.

As discussed previously, there may be cases where it may be desirable to use additional tractor-trailer trains. For example, when one tractor-trailer train transports 150,000 flat bales 1,500 feet, the equipment is used 1,755 hours requiring 5,265 man-hours (table 4). When two trains are used, the total equipment time is reduced to 1,245 hours (0.83 hour x $\frac{150,000}{100}$ bales, see page 9). The addition of one tractor-trailer train increases the equipment costs to $5.10 per hour (two 3-bale trucks @ $1.66 equals $3.32 and two trains @ $.89 per hour equals $1.78, see table 5). The total equipment cost for 1,245 hours is about $6,350. This compares with an estimated cost of $6,406 when one train is used. One additional tractor operator is needed, but the total man-hours are reduced from 5,265 to 4,980 ($\frac{150,000}{100}$ x 3.32, see page 9), a reduction of 285 man-hours. Thus, savings in both labor and time are possible when two trailer trains, and possibly more, are used instead of one.

Before purchasing transporting equipment, consideration should be given to the quantity of bales to be transported annually and the initial investment for equipment. The initial investment for a tractor and four trailers is considerably less than for the larger clamp trucks and a warehouseman may find that the quantity of bales to be transported and the warehouse facilities do not justify the higher cost for the large clamp trucks.

Table 4.--Estimated annual labor and equipment costs to transport flat and compressed bales of cotton for specified distances by large clamp trucks and tractor-trailer train 1/

Number of bales, distance transported, equipment, and unit loads	Equipment use	Labor required	Costs			
			Equipment	Labor	Total	Per bale
	Hours	Man-Hours	Dollars	Dollars	Dollars	Cents
100,000 flat bales transported 1,000 feet:						
Truck No. 2 with 12-bale unit load--						
Truck No. 2	450	450	2,286	608	2,894	2.8
Two 3-bale clamp trucks	700	700	1,554	945	2,499	2.5
Total		1,150	3,840	1,553	5,393	5.3
Tractor-trailer train with 16-bale unit load; two 3-bale clamp trucks	970	2,910	4,423	3,928	8,351	8.3
150,000 flat bales transported 1,500 feet:						
Truck No. 1 with 16-bale unit load--						
Truck No. 1	585	585	3,244	790	4,034	2.7
Two 3-bale clamp trucks	1,095	1,095	1,840	1,478	3,318	2.2
Total		1,680	5,084	2,268	7,352	4.9
Truck No. 2 with 12-bale unit loads--						
Truck No. 2	825	825	2,875	1,114	3,989	2.6
Two 3-bale clamp trucks	1,050	1,050	1,806	1,417	3,223	2.1
Total		1,875	4,681	2,531	7,212	4.7
Tractor-trailer train with 16-bale unit loads; two 3-bale clamp trucks	1,755	5,265	6,406	7,108	13,514	9.0
150,000 compressed bales transported 1,500 feet:						
Truck No. 1 with 20-bale unit load--						
Truck No. 1	510	510	3,091	688	3,179	2.1
Two 3-bale clamp trucks	1,125	1,125	1,868	1,519	3,387	2.2
Total		1,635	4,959	2,207	6,566	4.5
Tractor-trailer train with 16-bale unit load; two 3-bale clamp trucks	2,115	6,345	7,487	8,566	16,053	10.7

1/ Equipment use, labor requirements, and labor and equipment costs are computed separately for the two 3-bale clamp trucks when used with the large clamp trucks because the work is performed independently of the transport operation.

APPENDIX

Costs

Computations of handling costs in this report include only the direct labor and equipment costs for assembling and disassembling unit loads, loading and unloading of trailers, and transporting. Management, warehouse maintenance, overhead, and facility costs are not included; the cost data therefore do not reflect total costs to the warehouseman.

Labor costs are based on the time required to perform the operation and an assumed wage rate of $1.35 per hour for clamp truck and tractor operators. Wage rates in many areas differ from this assumed rate and warehousemen can substitute wage rates that apply to their own situation. No allowances were made in the assumed wage rate for such additional costs as pay for vacations and holidays, employer's contributions for old age and unemployment compensation, employees' insurance for life and health, and other fringe benefits.

Equipment costs are computed on the basis of ownership costs, which are considered to be relatively constant from year to year, and operating costs which are variable, as they directly reflect the hours of use of the equipment. Ownership costs consist mainly of depreciation, interest on investment, and taxes and insurance. The expected life of equipment was estimated from information obtained from Bulletin No. 14 of the Internal Revenue Service and from various warehousemen in different locations in the Cotton Belt. Operating costs include fuel, oil, servicing, repairs, maintenance, overhauling, and inspection.

Table 5 shows the estimated costs of ownership and operation of the equipment discussed in this report. In warehouses where a specified type of equipment, such as a 3-bale clamp truck, is actually used more than the annual hours of use assumed here for the transport operation, average hourly costs are probably lower. Conversely, average hourly costs are probably higher in warehouses in which the actual hours of use are less.

Labor Requirements

Data from Marketing Research Report No. 250, "Handling Bales of Cotton in Public Warehouses," supplement to MRR No. 250, "Statistical Supplement to Handling Bales of Cotton in Public Warehouses," and from additional later experiments and time studies were used to determine the requirements for loading and unloading trailers, assembling and disassembling unit loads, and for transporting over various distances using large clamp trucks. Table 6 shows the productive transport time for the large clamp trucks and a tractor-trailer train carrying different sizes of unit loads various distances.

Table 5.--Estimated costs of ownership and operation of handling equipment for various hours of annual use

Type of equipment and hours of annual use	Initial cost 1/	Expected life	Annual ownership cost 2/	Cost per hour of use		
				Ownership	Operation 3/	Total
	Dollars	Years	Dollars	Dollars	Dollars	Dollars
3,000-pound clamp truck:	6,300	8	1,105.00			
700 hours				1.58	0.64	2.22
970 hours				1.14	.66	1.80
1,050 hours				1.05	.67	1.72
1,095 hours				1.01	.67	1.68
1,125 hours				.98	.68	1.66
1,755 hours				.63	.78	1.41
2,115 hours				.52	.85	1.37
Large clamp truck No. 2:	10,000	8	1,700.00			
450 hours				3.78	1.30	5.08
825 hours				2.06	1.42	3.48
Large clamp truck No. 1:	14,000	8	2,380.00			
510 hours				4.67	1.39	6.06
585 hours				4.07	1.44	5.51
Industrial tractor and 4 trailers:	4,100	20	389.50			
970 hours				.40	.56	.96
1,755 hours				.22	.61	.83
2,115 hours				.18	.62	.80

1/ Initial cost does not include freight and tax charges.
2/ Allowance for insurance and taxes, 2 percent; allowance on average investment, 5 percent.
3/ Includes in addition to costs for maintenance and repairs, estimated costs for gasoline, or LPG, and oil at the following rates: 3,000-pound truck, 32 cents per hour; 10,000-pound truck, 62 cents per hour; 18,000-pound truck, 71 cents per hour; tractor-trailer and 4 trailers, 25 cents per hour.

Table 6.--Elapsed time required for 1 man to transport 100 bales of flat or compressed cotton different distances by large clamp trucks and by tractor-trailer train carrying different sizes of unit loads

Transport distances in feet	Clamp truck No. 2, flat bales, 12-bale unit load 1/	Clamp truck No. 1 2/		Tractor-trailer train, flat or compressed bales, 16-bale unit load
		Flat bales, 16-bale unit load	Compressed bales, 20-bale unit load	
	Hours	Hours	Hours	Hours
500	0.35	0.30	0.27	0.26
1,000	.45	.34	.30	.47
1,500	.55	.39	.34	.67
2,000	.66	.44	.37	.88
2,500	.78	.49	.40	1.09

1/ Includes 0.19 hour in each case to pick up and set down unit loads.
2/ Includes 0.22 hour in each case to pick up and set down unit loads.

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